

REMARKS/ARGUMENTS

The Examiner's Office Action and the cited references have been given careful consideration. Following such consideration, independent claims 30, 51 and 55 have been amended to define more clearly the patentable invention applicant believes is disclosed herein. Moreover, claims 57-59 have been added, and claim 49 has been cancelled by the present amendment. Claims 1-29, 32-36 and 42-47 were previously cancelled. Claims 31, 37-41, 48, 50, 52-54 and 56 are unchanged by the present amendment. It is respectfully requested that the Examiner reconsider the claims in their present form, together with the following comments, and allow the application.

Please note that amendments have been made to the specification and claims to correct typographical errors. In this respect, the term "silicon rubber" has been amended to "silicone rubber." No new matter has been introduced by this amendment.

The applicant's representative wishes to thank the Examiner for the courtesies extended during the telephone interview conducted on November 29, 2007. The comments provided below are directed to the issues discussed during the telephone interview. As suggested by the Examiner, the comments include a discussion of how the dielectric layer 404 of Gengel (US 6,417,025) could not function as a "buffer layer" to release stress. To this end, the applicant submits herewith a Declaration Under 37 C.F.R. 1.132 executed by one of the inventors of the present application, Wen-Kun Yang. The Examiner is respectfully requested to give careful consideration to the information provided in the Declaration.

Claims 30, 51 and 55 are the only pending independent claims of the present application. It should be noted that independent claim 30 has now been amended to incorporate limitations from dependent claim 49 (now cancelled). Accordingly, claim 30 recites "a first dielectric layer formed on said base and filled in a space except said die on said base, wherein the first dielectric layer includes *silicone rubber, epoxy, resin or BCB to act as a buffer layer to release stress.*" Similarly, independent claims 51 and 55 include the limitation requiring "a buffer layer formed on said base and adjacent to said die to release stress, wherein said buffer layer includes *silicone rubber, epoxy, resin or BCB.*"

It should be appreciated that the "first dielectric layer" (claim 30) and the "buffer layer" (claims 51 and 55) are important aspects of the present invention. As will be appreciated from a

reading of the *Specification*, the present invention is directed to a fan out type wafer level package (WLP) structure. Most package technologies assemble the package of each die after wafer dicing. In a wafer level package, dies are packaged on a wafer before wafer dicing, i.e., prior to singulation of a wafer into individual dice. It is desirable to encapsulate a die at the wafer level in order to avoid damage to the semiconductor device that may occur during separation and packaging processes.

One important function of a package structure is to protect the dies from external damage. Moreover, the heat generated by the dies must be diffused efficiently through the package structure to ensure proper operation of the dies. It is one object of the present invention to avoid problems relating to signal coupling and signal interference, and to raise the yield of the package structure. As discussed in detail below, the first dielectric layer (claim 30) and the buffer layer (claims 51 and 55) of the claimed invention reduce stress due to such conditions as temperature changes.

Claim Rejections-35 U.S.C. 103

The Examiner continues to reject the claims of the present application on the basis of Gengel (US 6,417,025). In particular, claims 30, 31, 37-41 and 48-56 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Gengel. It is respectfully submitted that Gengel fails to anticipate or render obvious the applicant's claimed invention.

Gengel's dielectric layer 404 is comprised of silicon dioxide or polymers, i.e., polyethersulfone (PES) or polysulfone (PS). Thus, the Examiner acknowledges that Gengel fails to teach a first dielectric layer or a buffer layer that includes silicone rubber, epoxy, resin or BCB for the release of stress. The Examiner argues that it would have been obvious to one of ordinary skill in the art to use the recited materials in the invention of Gengel, "because silicone rubber, epoxy, resin or BCB are known equivalent dielectric materials." It is further stated by the Examiner that the substitution of one known equivalent technique for another may be obvious even if the prior art does not expressly suggest the substitution.

With regard to the claimed "first dielectric layer" (claim 30) and the "buffer layer" (claims 51 and 55), it is respectfully submitted that Gengel fails to teach or suggest an equivalent structure that serves the function of releasing stress. As acknowledged by the Examiner, Gengel's dielectric layer 404 does not include silicone rubber, epoxy, resin or BCB. In this respect, Gengel discloses

silicon dioxide and polymers, such as polyethersulfone (PES), and polysulfone (PS) as materials for first dielectric layer 404.

It is respectfully submitted that due to the different properties of the materials for Gengel's dielectric layer 404 and the materials of the claimed "first dielectric layer" (claim 30) and "buffer layer" (claims 51 and 55), the materials disclosed by Gengel do not function as equivalent materials to those of the claimed "first dielectric layer" and "buffer layer." For example, the material properties (i.e., tensile strength, Young's Modulus, glass transition temperature, stress index, elongation at break and coefficient of thermal expansion (CTE)) of silicone rubber are significantly different from the material properties of Gengel's silicon dioxide PES and PS. The Declaration under 37 C.F.R. 1.132 submitted herewith provides further details regarding the properties of the various materials.

The glass transition temperature (T_g) of a non-crystalline material is a critical temperature at which the material changes its behavior from being "glassy" to being "rubbery" (i.e., elastic and flexible). Thus, at a temperature above the glass transition temperature, a material behaves in a rubbery state. As indicated in the attached Declaration Under 37 C.F.R. 1.132, the glass transition temperature of silicone rubber is -60°C , whereas PES and PS have a glass transition temperature that exceeds 220°C .

Young's Modulus is a measure of the stiffness of a material, wherein a higher Young's Modulus indicates a greater stiffness. As noted in the attached Declaration Under 37 C.F.R. 1.132, the Young's Modulus for silicone rubber is less than 20 MPa. Silicon dioxide, PES and PS all have significantly greater values for Young's Modulus.

Tensile strength of a material is the maximum amount of tensile stress that the material can be subjected to before failure. As indicated in the attached Declaration under 37 C.F.R. 1.132, the tensile strength of silicone rubber is significantly lower than the tensile strength of silicon dioxide, PES and PS.

The coefficient of thermal expansion (CTE) describes how much a material will expand for each degree of temperature increase. As indicated in the attached Declaration under 37 C.F.R. 1.132, the CTE for silicone rubber is approximately 200 ppm/ $^{\circ}\text{C}$, which is significantly greater than the CTE for silicon dioxide, PES and PS.

As discussed in the paper entitled "Design, Experiment and Analysis of the Solder on Rubber (SOR) Structure of WLCSP" (filed in the IDS accompanying this Response), there are many advantages to a solder on rubber (SOR) structure. For example, such material has the capability of releasing deformation energy caused by a coefficient of thermal expansion (CTE) mismatch between the silicon chip and the substrate.

The other claimed materials (i.e., epoxy, resin and BCB) for the "first dielectric layer" (claim 30) and "buffer layer" (claims 51 and 55) also have similar advantageous material properties.

In summary, the materials for the claimed "first dielectric layer" (claim 30) and "buffer layer" (claims 51 and 55) have properties that allow for the release of stress. Such properties are not found in the materials disclosed by Gengel.

The Examiner also acknowledges that Gengel fails to teach the claimed "adhesion layer" located between the die and the base. Accordingly, the Examiner relies upon the argument that an adhesion layer is conventionally well known to a skilled artisan to allow for a strong bond to the base. The Examiner further states that the use of conventional materials to perform their known functions is obvious. Furthermore, the Examiner has cited Quirk et al. (Semiconductor Manufacturing Technology) in support of the argument that an adhesion layer is conventionally known to skilled artisans and is used to attach a die to a substrate.

With regard to the claimed "adhesion material," it is respectfully submitted that none of the prior art cited by the Examiner discloses the use of an adhesion layer in connection with a fan out type wafer level package structure as required by independent claims 30, 51 and 55. With respect to the Quirk et al. reference, this reference shows use of an adhesive for attaching a die to a lead frame or substrate in a wire bonding/molding application. In contrast, the adhesion material of the claimed invention is used in connection with a fan out type wafer level package structure.

Turning now to Gengel, it is respectfully submitted that due to the lack of adhesion material between silicon die 410 and layers 404 and 406, stress caused by temperature cycling will result in "squeezing" of the die out of receptor region 408 (e.g., see FIG. 4N). This squeezing will occur because of the mismatch between the CTE of the die and the much higher CTE of the materials of layer 404. Moreover, the shape of the die relative to layer 404 will also facilitate squeezing of the die out of receptor region 408. Accordingly, it is respectfully submitted that Gengel's dielectric

layer 404 is not equivalent to the claimed “first dielectric layer” (claim 30) or “buffer layer” (claims 51 and 55) due to the different material properties.

Furthermore, Gengel’s conductive elements 424 are located lateral to a conductive layer, and thus make contact with the side wall of the conductive layer, whereas the solder balls of the claimed invention are welded on the conductive lines. It is respectfully submitted that welding of the solder balls on the conductive lines provides a more reliable connection than the arrangement disclosed in the Gengel reference.

The claimed “first dielectric layer” (claim 31) and “buffer layer” (claims 51 and 55) in combination with the claimed “adhesion material” address the problems caused by thermal stress. Gengel’s die will dislocate due to thermal stress as a result of the material properties of the dielectric layer 404 and the lack of an adhesion material to maintain the die within receptor region 408.

Moreover, Gengel’s dielectric layer 404 is formed on the surface of a thermally conductive layer 406 comprised materials such as aluminum, or other metals or metal alloys, including copper, copper-beryllium alloys, molybdenum, nickel, INVAR, INCONEL (see column 4, lines 5-22). In contrast, the claimed “first dielectric layer” (claim 30) is formed on a base that may be comprised of such materials as glass, silicon, ceramic and crystal materials (see dependent claim 39).

In view of the Declaration Under 37 C.F.R. 1.132 and the foregoing comments and amendments, it is respectfully submitted that dependent claims 1, 51 and 55 are not obvious in view of Gengel. Moreover, the remaining claims depend from independent claims 1, 51 or 55. Thus, it is respectfully submitted that these dependent claims are likewise patentable over Gengel for at least the reasons discussed above in connection with the independent claims.

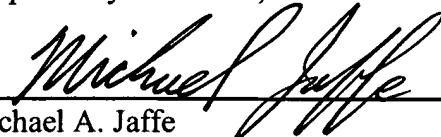
It is respectfully requested that the Examiner now withdraw the 35 U.S.C. 103 rejection based upon Gengel, and issue a *Notice of Allowance* in the present application. If the Examiner believes there are any further matters that need to be discussed in order to expedite the prosecution of the present application, the Examiner is invited to contact the undersigned.

Please note that an **Information Disclosure Statement (IDS)** accompanies this Response. The Examiner is respectfully requested to consider the reference cited therein.

If there are any fees necessitated by the foregoing communication, please charge such fees to our Deposit Account No. 50-0537, referencing our Docket No. HK9225US.

Respectfully submitted,

Date: **February 26, 2008**



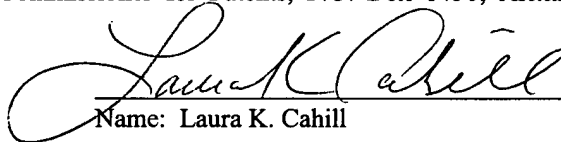
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I hereby certify that this correspondence (along with any paper referenced as being attached or enclosed) is being deposited on the below date with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

Date: **February 26, 2008**



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